



Functional to Fashionable: Knitwear's Evolution throughout the Last Century and into the Millennium

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ABSTRACT

Since the days of the humble hose, knitwear has expanded into a revolutionary industry that is classified within the high fashion category. This paper presents an investigation into knitwear's evolution, which can only be described as remarkable from functional items of clothing to fashionable cutting edge styling utilizing the most advanced technology. The first obvious sign of knitwear changing its role from functional to fashionable, occurred during the latter part of the 19th century and the early part of the 20th century, and since then knitwear has never looked back. The 1920s brought about the birth of the classic twin-set promoted strongly by the English gentry and reinforced by a huge advertising campaign that pushed knitwear irrevocably to the forefront of fashion. The 30s remained quiet in terms of knitted fashion whilst the knitwear industry struggled to survive against the cheaper foreign imports. By the mid 30s the industry had recovered and had become ever more directional. However, it was not until after the second world war that a strong push was made in terms of design education to promote knitwear as a fashion item in its own right (rather than a mere accessory). Post the Second World War, fabric was in abundance and the classic knitted twin-set once again became high fashion with American film stars promoting the sophisticated image of knit. What a pity by the time we arrived at the forward thinking 50s we had not yet developed the electronics to support the innovation. Pioneers in the field of 3-D development were hindered by the lack of technology during this period and to some extent the technology did not materialize until the birth of the new millennium.

Keywords: Knitwear, Technology, Knitting, Functional Clothing, Fashion Knitwear, Evolution

Functional knits

Many Authors have traced the knitting of leg coverings back to 15th and 16th century men's fashions ^[1,2]. However, the coarse woolen structures experienced a low comfort factor in terms of the human physiological requirements and therefore

could probably be identified as functional clothing rather than items of fashion. The thinner, more comfortable woven bias cut versions were later adopted as a general trend primarily for factors associated with comfort and improved production. The first notable influence of knitted goods in relation to true fashion was credited to the birth of

the fully-fashioned hand knitted silk hose – this had a dramatic effect in terms of aesthetic qualities, which was further exploited during the Elizabethan era by rich embellishment to imply status and wealth; Perhaps this is the first example of designer knitwear history can provide. Brackenbury reports that individuals spent half their yearly income on a single pair of hose, thus indicating the desirability of the product ^[1]. This provides us with Lee’s reasoning for beginning the developments that led to the mechanical action of knitting and eventually the birth of the stocking frame in 1589. It should be noted that hand knitting was still practiced extensively even after the commercialization of Lee’s frame around 1620 ^[1]. However, it diversified into coarser products for crafts and outerwear.

There is also evidence that the hand knitting skills developed by the Spanish sailors during the 16th century became common practice in ports around the globe ^[1]. Again this provides us with evidence of knitwear’s place in history as functional clothing. Garments produced for seamen served as barriers meeting requirements in terms of protection and warmth without restricting bodily movement ^[1,3].

Knitwear changing roles

The first obvious sign of knitwear changing its role occurred during the latter part of the 19th century and the early part of the 20th century. Important developments occurred in English dress that changed the role of knitwear forever. Men’s dress shifted from tights to trousers, obviously having a significant impact on the knitted hosiery industry. The knitters were forced by the change in fashion trends to diversify into new markets. This was an important period in knitwear since the manufacturers had to indulge in new product development leading into the women’s wear market. By 1910 knitwear was established as an item of fashion in the modern women’s wardrobe, the idea of knit to fit (i.e. the concept of

fully-fashioning) was completely accepted in social circles ^[1].

During the same period of innovation, there were significant developments in circular knitting machines, which led this method of production replacing the frames production of half-hose and socks ^[3]. Most of the mechanical operations on the circular machine became automatically controlled and by the year 1915, even welt turning became a reality. The manufacturers of the straight bar frame responded by creating coarser gauges to produce underwear. This brought with it the opportunity to experiment with processes to create a whole new shaping technology and garment fit. New styles of underwear, such as the union suit immersed (men’s under vest and pants) ^[3]. By 1914 the transition from a domestic cottage industry to a factory system was virtually complete in hosiery ^[4]. The coarser gauge machines used for underwear provided advanced shaping technology, which could be manipulated to create 3D shapes. Individual styles began to evolve from the different shaping methods regarding garment fit and unique styling. Around this time there were advancements in machinery that created mixed options with scope for individual interpretation. Underwear existed where shaping was achieved through a combination of methods (fully-fashioning and changing structures); this provided a unique styling opportunity for design. It was apparent during this period that much had been learned from the toe shaping from the prior decade. The new styles of the era “raglan sleeves” first appeared around 1912 generating trends in hand knitting, this was acknowledged as a well fitting style line and even today remains popular. There was also the controversial development of “cut and sew” knitwear, which caused immense unrest in knitwear manufacture especially in Nottingham ^[1], which was not truly accepted until some later years.

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The prosperous war

The war years (1914-1918) proved to be prosperous for the knitwear industry with many manufacturers working on government contracts for hosiery and underwear. The demand for woolen jumpers with no fastenings, which could be pulled over the head, was boosted^[5], probably due to lack of supplies and manufacture of fastenings. Some authors classify this as the make-do and mend era in terms of knitted fashion innovation and recognize that much in terms of fashion direction was owed to the skills of hand knitting^[3].

Generally after the war knitted goods took two directions 1) cut and sew, and 2) knit to shape (fully-fashioned). Fashion had suffered from the shortage of materials during the war, this gave birth to a new era with the likes of Chanel at the helm. Skirts rose six inches off of the ground by 1916 opening a new era in innovation and trend^[6]. In terms of knitted fashion there was a strong masculine influence, this was the age of jersey, tubular functional dresses were fashionable, which did their utmost to obliterate waistlines, hips and busts^[7]. The designer Gabrielle Chanel contributed significantly to jerseywear developments in the 1920s. In 1926 she introduced her “little black jersey dress” and for the first time hemlines were cut at knee length^[6,8]. Chanel took the fabric previously used for men’s underwear into the realms of high fashion ladies daywear, which was cut and sewn together^[3]; this probably influenced the growth of cut and sew. Circular knitting machines were producing plain fabric for cut and sew garments, however, effort was directed to more versatility around this time, electric cutters became available to speed up the process^[4]. Other circular produced knitted fabrics became popular such as brushed structures. During this period there was significant development in the garment make-up, flatlock seams were introduced which created a fine join in comparison to the overlapped seam. ‘This innovation did much to enhance the status of cut and sewn

goods, especially when made from high quality fabric like interlock’^[4]. Around this period there was a boom in American manufactured machines, integral knitting in the form of producing stockings with the heel and toes shaped during the loop forming operation became popular and hosiery produced around that period in the UK became dependent on these machines. The old complaint of low-quality hosiery, which had frequently been a cause of concern in the old days, reappeared again but was directed against Japanese imports, which had a decisive advantage in international trade because of the combination of modern machinery and low wages^[4].

Knitted underwear and hosiery continued to generate income after the war. However, Millington reported that it was only moderately successful and the salvation was in reality the ‘great leisurewear boom’ that occurred in outerwear shortly after the war^[1]. Capital was invested in the knitwear manufacturing industries around 1918/19 which led to extensive factory expansions; there was an inflationary boom, which caused selling prices to rise faster than production^[4]. Quality underwear producers in Scotland diversified into high-grade outerwear produced in rare wools for both export to American and French design houses and for their own classics^[3,6]. The amount and variation in styles and colors increased rapidly to provide a wide range of outerwear^[7]. Mason acknowledges that only high quality yarns are used in fully-fashioned goods because of the costs involved in their production (1981)^[6]. This obviously limits knitwear’s influence on fashion and would explain why fashion turned to the less expensive jersey fabrics for inspiration, and the reasoning behind the vast variation in fabric quality.

The birth of casual dress

Hosiery suffered a series of sharp setbacks due to the new fashions and cultural change. Men’s fashions changed from breeches to

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trousers in the early 20th century and ladies skirts got gradually shorter ^[9]. During this period there is evidence of women claiming ever more independence, which was reflected in the masculine stylelines in vogue ^[8]. Although the hosiery market was general shrinking, the market share of silk and rayon (which offered a substitute for silk) was growing in the UK, as rayon from America became commercially available from 1924 ^[9]. 'The art and volume of advertising multiplied in the years between the wars, and hosiery and knitwear manufacturers were not slow to exploit developments that were already moving in their favor' ^[9]. It is not difficult to find reasons for the adoption of knitwear for such activities, many authors acknowledged the inherent qualities of knitwear in terms of; comfort, freedom, elasticity, and durability (amongst others) ^[1,2,3].

The post war knitwear boom had collapsed by the early 1920s ^[4]. Knitting goods were forced to diversify into other markets, the most notable being casualwear. Influence was taken from the wealthy British country lifestyle and the landed gentry, enabling the traditional English and Scottish high-class manufacturers to supply the world markets with their quality knitted goods ^[3]. The classic casual look soon developed into the sport look, which was strongly promoted by intensive advertising campaigns. A major advertising campaign took place in 1930 featuring middle class families wearing the new casual knits whilst engaging in a variety of leisurely pursuits ^[7].

During the 1920s knitted fashions were split into two style trends; classic items such as the stylish twin-sets for ladies wear, which was aided by machine developments such as the new attachment to produce the V-neck shape ^[2]; and knitted sportswear ranges which featured the new technologies of the era, 1926 saw the introduction of the '...first motor-driven jacquard flat machine' ^[2], which allowed patterned knitwear production. At the beginning of this period Australian high grade wools were popular,

however, by the mid 20s cotton was a common choice for outerwear, taking its influence from the causal lifestyle. By the mid 20's there was a move towards fancy, novelty garments and manufacturers satisfied this by utilizing special fibers such as angora, vicuna, camel and alpaca. However, at the dawn of the 1930s it was Scottish cashmere that dominated high quality knitwear, which was popularized by Pringles, Jaeger and the other classic British manufacturers ^[7]. However, it was Pringle who first realized in the late 20s that continental fashion was growing rapidly, and so in 1934 in order to stay ahead of the competition the Austrian designer Otto Weiz was appointed. Otto was responsible for the first styled range aimed at the continental market ^[3,7]. Hence, designer knits were born.

Knitted underwear

The end of the 20s threatened the British underwear industry with cheaper foreign imports. To ensure the stability of the British knitting trade importation duties were introduced on all imported knitted goods from 1931 ^[4]. This enabled British hosiery and knitwear industries to grow, which were assisted by the fashion trends of the era ^[4]. Skirts got shorter thus there was a requirement for stocking, many stockings were produced from silk but there were rapid improvements from rayon enabling a less expensive version to be produced that were finer, these were less durable than the silk counterparts, however they met the fashion needs. The circular knitted hose was developed but there was still bagginess around the ankle area and it was for this reason that they were considered inferior to the traditional fully-fashioned stockings produced on the straight bar frame ^[2]. By the mid 30s the British knitting industry had recovered from the general depression of the early years, production of hosiery increased by half, but underwear almost doubled ^[9]. Underwear sales grew with the rise in living standards (and cheaper production methods, cut and sew on circular machines) and more variety was demanded by the consumer to

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match the trends in outerwear. ‘Spiers produced a successful machine of this type in 1930, termed the Spensa Purl machine’^[2]. This machine was a circular weft knitter capable of producing purl structures with tubular welts and rib borders. Wools were replaced with less expensive and lighter cottons and rayons; this prompted the popularity of cotton underwear^[4]. During this period cotton interlock was patented as a new fabric, this was remarkably fine and soft in texture, which made it an expensive fabric^[4]. Rayons growing popularity was evident in stockings – silk was still the best fully-fashioned hose but for mass demand circular (seamless) rayon was next best^[4]. By the end of the 30s millions of underwear garment were produced on the circular overlock machines^[7]. Wells acknowledged that during this era knitted outerwear garments were less important, ‘...but the vogue was beginning’^[4]. During the years between the two world wars knitwear was mainly a woman’s market with men’s items only required in the form of sports shirts, pullovers and cardigans^[4]. In terms of styling this was the era of detailed shaping, fitted waists slightly broader shoulders and intricately shaped necklines. It was were woven styles began to be mimicked into 3-D knitted goods (most women were proficient dressmakers), darts or holding began to appear which were part of the knitting pattern. Sweaters were short, knitted with rib texture, short sleeves and ties necklines proved popular. This was an important era in terms of the shift from functionality to fashion. ‘The tendency for woolen underwear to be supplanted by fancy woolen outerwear, noted in the inter-war period, continued after 1945’^[7]. It was noted at the end of this period that there was a lacking in design education to move the industry forward in line with hand knits^[7].

The war years and synthetics

The early war years saw a sharp decline in hosiery and knitwear^[4] this was an era of make do and mend with rationing on clothing introduced in 1941. During this era

hand knitting was again popular with style lines turning to short sleeves, due to the lack of resources. 1941 saw a decline in silk stocking and their cheaper counter parts (cotton and rayon) were soon in short supply because of the problems effecting imports during the war. This encouraged the bare leg look or hand knitted footlets. The era after the second-world war had a massive impact on the hosiery industry with the introduction of Nylon commercially^[9]. The most attractive feature of nylon is its ability to be given a permanent set – the value being to the nylon hose^[6]. Nylon’s thermoplastic properties allowed a seamless hose to be produced and heat set (in addition it was cheap, strong, fine and uniform). Hence, the classic fully-fashioned hose had no longer a place in the fashion market. Courtauld’s and ICI had licensing agreements with Dupont from 1939 but it wasn’t until the completion of a new plant in 1948 that major scale production for the Nylon begun in UK changing the face of stockings for ever^[6].

Outerwear saw a dramatic change in styling as hemlines returned to the ankles during the 40s, this obviously required more fabric and yarn, Christian Dior introduced his new look – fitted skirts, which finished 16 inches from the ground^[9]. During this period Hollywood played a highly influential role in fashion knitwear. The film stars of the day and other celebrities were sent the classic twin-set^[7]. It provided glamour and glitz to classic knit silhouettes bringing them into mainstream fashion by introducing the sweater girls^[3]. Gulvin quotes a letter from Deborah Kerr in 1949 thanking Pringles for the twin-set^[7]. This styling exploited the natural stretch properties within the knitted structure to produce figure, skimming sweaters^[3]. However, yet another crises hit the knitwear market in the early 50s (Korean war) and with it came increases in wool prices, which contributed, to a worldwide recession in textiles^[7].

The years after 1953 saw a peak in the British hosiery industry, nylon fully-fashioned stockings produced on straight bar

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frames became finer and productivity rose^[2]. This was prompted by the advancements of the circular heat-settable seamless stocking, the problems of bagginess was solved heat shaping could now occur. This was one of the dramatic changes in the knitting industry^[2]. Fashion styles became simpler so did machines and make-up techniques in hosiery. However, fashions progressed and by the end of the 50s the bare leg look was the rage^[2]. This is confirmed by Brackenbury were he states ‘...ladies hose which suffered a dramatic eclipse in the early 1960s when a fashion change wiped out an enormous industry virtually overnight’^[1]

A new word in fashion

Mid 50s a new word entered the fashion arena “casual”^[10], separates became the trend, (i.e. a skirt and matching unstructured top) – these were commonly referred to as jumper suits. Acrylic became popular because it could be blended with wool in outerwear garments producing easycare garments. Dyeing and finishing techniques also improved around this time extending the present use of raw materials^[4]. Lycra became a commercial reality with its properties suited to the casual market. The Dolman sleeve sweater of the 50s, which had wales, that ran in the vertical direction rather than in the horizontal became high fashion^[1]. This style line (with folds developing under the arms and around the tightly constrained waist) was produced from plain knitted fabric. The advantage of plain fabric was its drapeability and ease of bending in both planes^[1].

Until the mid 50s warp knitting had tended to be small, however ‘the development of the modern specific-purpose raschels dates from 1956, when a 12 guide bar raschel machine led to the rise of the raschel lace industry’^[2]. In addition to developments in warp knitting, weft knitting had some innovation of its own the first purpose built double jersey circular machine which could produce knit, miss and tuck stitches was

introduced, opening up patterning possibility as previously unseen^[2].

It is interesting at this point to report, “...berets were the rage of New York”^[10]. Further to this we can see attempts by knitwear pioneers to advance the machine technology. Macqueen patented his idea to use the Basque beret technique (flechage) for producing outerwear in the late 50s^[25]. Emma Pfauti based her concept of complete garment around a yoke^[25]. However, the technology of that era was not advanced enough (variable stroke was a significant problem). There appears to be evidence from Essingers account of working life that couture cardigans from Paris “Elsa Schisparelli” (designer label) around late 50s were knitted in one piece with no seams “...there were no seams anywhere because the welt, sleeves and stole were knitted into the shape”^[10]. Essinger goes on further to described the fit as superb “...sitting so lightly on the waist and shoulders you hardly knew you were wearing it”^[10]. During the 50s large companies such as Courtaulds and ICI boomed, with M & S setting the quality standard; and BHS / Littlewoods producing cheaper products. The 50s was very much about machine development, faster speeds, and increased patterning opportunity. If only the electronics could have developed in-line with the 50s innovation, who knows were knitted fashion would have been now.

The diversification of the industry

The swinging 60s brought wealth and prosperity to all sectors of the knitting industry. Due to the technical advancements of warp knitting machinery during the late 50s, it has been reported that by the 60s this was the fastest growing section of British hosiery industry incorporating mainly man-made fibers^[4]. This industry directly competed with woven and by 1969 it was estimated that 50% of men’s shirts were made from warp knitted fabrics^[4].

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There were also significant diversifications in weft knitting by the early 60s, the cotton patent machine is reported to have abandoned hosiery production in favor of outerwear^[9]. During the mid years 18 firms from the hosiery industry^[4] had been taken over, which demonstrates the wide diversification and modification of the industry. Courtauld and ICI grew and so did Coats Paton whose success was attributed due to Jaegers triumphs as a retailer – one third of Jaegers payroll were employed on knitwear manufacturer^[9] and Otto Weisz led Pringle to expand into men's fashion in 1961/62. During the 60s Scottish knitwear grew dramatically and UK exports grew and more than doubled between the mid years^[4] this obviously influenced diversification into specifically designed export ranges. The USA is reported to have responded to this new development faster than UK particularly in men's fashion, therefore a substantial export trade was established^[4]. In addition to the diversification of weft knitting into the outerwear sector the 60s is credited as the double jersey/jacquard boom, this structure created a shift from woven fabrics to knitted fabrics. This was the advantage of the new technologies, and machine builders (Bentley, Stibbe-Monk and Kirkland) had many patents in needle selection mechanisms to carry out the function of lifting needles to knit or leaving them down to miss during this period^[1, 9]. During the decade from 1963 the yarn consumption in double jersey increased especially filament type yarns such as crimplene polyester this assisted in placing polyester knitted items at the forefront of female fashion and by 1969 double jersey had over 50% of the knitting market^[1, 2]. Hence, here fashion was machine led – without the machine innovation these mechanisms would never have enabled fashion to have machine jacquard. Again the properties of the knitted structure were exploited; the stretch nature of rib structures gave rise to a figure-hugging silhouette that wovens could not achieve. 'The period from the mid-1960s to 1973 is often regarded by knitters as a golden age because fashionable

demand for textiles composed of synthetic fibers reached a peak during this period'^[2]. This era is credited to the black poloneck sweater and Benetton's colorful ranges^[3]. It wasn't until the mid 70s that the jersey bubble burst partly due to the Italian designers who were becoming recognized internationally for their classic knitwear styling^[3].

The advent of the mini skirt by the mid sixties again effected hosiery production as individuals moved from wearing stocking to self-supporting tights^[2]. This prompted innovation and advancement in hosiery machinery, and by 1967 toe closing was possible on the circular machine^[2]. During the 60s Pretty Polly rose to be the leading company in UK hosiery, assisted by the launch of hold-ups in 1967^[9]. By the late 60s Pretty Polly had commercially produced the "banana type panty hose" (one-piece tights)^[1,2].

Moving to the later years there was a great belief in the industry that new technology must be found to drive the knitting machine forward. The concept of pressing the knitted stitch prior to loop formation was becoming reality. The Courtauld's team led by Frank Robinson developed the presser foot. This opened up a whole new era for knitted patterns and stitch holding techniques. It was found that it was possible to begin knitting on empty needles with the assistance of a mechanical device. However, their patent relating to the production of seamless garments by producing tubes prevented other from developing the idea further^[1]. These early technological advances are now a standard on modern knitting machines, but it took them twenty years to evolve into what we see today. The vogue of the period was now producing simpler garments, which called for less sewing and cutting out. Two important machine developments in this era were the launch of the Protti PDE flat knitting machine at ITMA, which stunned the world. It was the first example of needle selection

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by electro/mechanical means and Shima's seamless glove machine ^[2,11].

The golden knits

During the early 70s an unsuccessful attempt was made to break into the US men's leisurewear market with double jersey structures produced from filament yarns. 1973 saw the peak of double jersey produced from filament yarns and the over expended industry failed to penetrate into new area ^[2]. Ladies fashion around this time was turning back to natural fibers produced from woven cloth; hence knitwear was not the craze ^[2]. By the early 70s Milan had risen to be the fashion capital of the world. Italian knitwear such as the sophisticated unique style of Missoni was highly promoted in international publications such as Vogue and was the talk of international fashion conversation ^[3].

During the 70s worldwide production was greatly influenced by knitwear designers ^[3], this opened up the mainstream fashion markets to the knitwear industry, thus providing scope for innovation and new technological development ^[3]. Black associates the technological drive with design development ^[3], but it is clear from the earlier decades that technological advancement pushed opportunities for design as a method of survival, and post war design education began catching up and utilizing the available technology. During the 70s knitwear boom, strong influence was taken from the direction of hand knitting, Patricia Roberts, Sarah Dallas and Marion Foale assisted knitwear back into mainstream fashion ^[3]. From the early 80s there was a revival of hand knitting with a strong emphasis on individualism. Black states, in the 70s and 80s it was clear that design developments led technical progress ^[2], but in reality it was a partnership between technology and design driving the industry forward? The gap was closing.

Many British designers found new international markets in Japan and America

^[2]. According to Black an '...explosion of new ideas created a shift, as knitwear markets polarized into the older age-groups buying classic and traditional knitwear and the growing younger, fashion-oriented consumer buying 'items' for impact – often colorful, hand-knitted, patterned sweater' ^[2]. The early 70s saw skinny ribbed knitwear in cut and sew styles with synthetic yarns, which were highly promoted both by the manufacturers and fashion outlets. This was not a challenge to technology but was a move away from the basic classic sweater of the 60s. Knit altogether became sexier for the young and carefree. 1975 saw 'the first fully electronic flat machine' ^[2]. This enabled jacquard patterns to be produced from "jacquard steels" which enabled colored motifs to be combined with other stitch variations. According to Brackenbury knitwear dominated fashion in the late 70s and early 80s ^[1]. Kenzo wrapped the fashion conscious women in brightly colored knit layers in the Jungle Jap label ^[3]. There are other examples such as Coogi (Australian company) utilizing a man's sweater that combines color (in the form of jacquard) and texture which is only achievable through partial knitting ^[3], which was still expensive to produce during this era. 'However, in cut and sew knitwear it faced competition from the less versatile but more highly productive circular garment-length knitting machines. Additionally in the production of classic, plain fully-fashioned knitwear it was unable to challenge the shaping facilities of the straight bar frame' ^[2].

Even knitted underwear slowly was subjected to fashion changes and became what we know today as the T-shirt ^[1] but this was much less than a challenge for technological advancements. It has been suggested that over the last twenty years the revolution in modern knitted fabrics has come directly from the integration of elastic with enhanced functionality ^[3]. The rise in the fitness boom of the 80s was translated into fashion using spandex blends in jersey knits, according to Black they created a new

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wave of energy in club culture – eventually rolling out into sportswear ^[3].

The fashion led market

The mid 80s brought a new fashion led market hammering costs down, and thus bringing fashion within the grasp of the majority of the population ^[9]. The big name in knitwear was now Benetton an Italian retail chain and in the UK NEXT and Gap grew. Power dressing became popular as knit moved away from the figure hugging silhouettes into a casual comfort zone. The styling thus became softer and oversized often with large colorful imagery. This was classed as a basic wardrobe item and was a key design icon of this period. Low cost manufacturing countries (Turkey) gained momentum entering into the mass production market there was a large investment of machinery at the start of the 90s, which peaked, in the mid years ^[12]. During the late 90s the Turkish knitting sector entered a general restructuring and reached the capacity of today's markets ^[12]. The technological development in the weft-knitting sector that had begun in the somewhat earlier years now became more driven as the developing UK and European markets struggled to survive against increasingly cheaper export.

'The advent of computer controlled V-bed knitting machines has changed the situation dramatically' ^[1]. In the 80s simpler programming systems were devised, cam boxes refined and stepper motors introduced to control stitch length ^[13]. A research program was developed between Shima and Courtaulds (1985) to develop integral garments ^[13]. 1987 saw 'the first of the CMS series machines' ^[2]. This machine was important for its holding down sinkers and new reversible motor technology to knit short strokes were the cam box only moved over the active needles ^[13]. This machine was sold very much due to its ability to knit 3-D structures. There was a change from the concept of fully-fashioning only being used on quality yarns, to fully-fashioning entering

the fashion arena with cheaper synthetics being used. 'The ability to fully-fashion on a wide range of fabric types is now possible' ^[1]. Knitting machines now had stitch length control, patterning versatility and controllable takedown mechanisms.

However, the technological developments, which had been crucial to the continuous reinvention of industrial, knitting from its humble beginnings, were hampered by two factors. Brackenbury outlined these to be firstly the skills of the designer and the technician's ability to program complex patterns and secondly the time factor - prototypes take longer to develop ^[1]. This idea is later confirmed by Black '...but now designers and technologist struggle to keep up with the opportunities afforded by the latest technology' ^[3].

The return of comfort dressing

The early 90s moved away from the power dressing masculine style lines of the 80s to comfort dressing. Brackenbury acknowledged in the early 90's that 'it would be very difficult to find individuals anywhere who are not wearing at least one knitted article' ^[1] in further investigation it was discovered that most individuals wear at least 2 knitted items every day. This was aided by M & S working with Dupont to create an important commercialization; introducing Lycra yarns to the mass market, initially in hosiery, sportswear and underwear and then into suits ^[9].

Quality knitwear found its place in formal dress as well as fashion. The classic twin-set has come back to create a comfortable classic with different twists in terms of materials, patterns and proportions ^[3]. Decorated (beaded) cardigans were an important accessory during this period creating an opening for classics in the eveningwear sector ^[3]. Again the branded British classics came to the forefront of fashion, Jaeger, Pringle, Ballantyne and John Smedley, the English gentlemen look was translated into many collections. Each

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brand worked in unison with a designer to create an inspirational range that had appeal to the younger market. Vivienne Westwood collaborated with Smedley and created a classic Argyll pattern under the umbrella of the ‘voyage to Cythera’ collection ^[3]. It combined a classic fully-fashioned Smedley twin-set with knitted long johns in a bold Argyll pattern. The likes of Clements Ribeiro reinvented cashmere with bold patterns and colors ^[3]. During this period, style and fit were extremely important, it was very much about body beautiful and silhouette, new inset sleeves manipulate the knitted structure and skinny ribs become the style of the classics, creating a unique styling.

Within knitted fashion there was also a strong influence of deconstruction and transparencies creating a suckle nudity in fashion ^[3]. For examples turn to Lainey Keogh, Lagerfeld and Galliano. In addition Macdonald created some interesting knit designs based on transparencies ^[3]. By the mid 90s overdyed fine gauge knitwear, trimmed with feminine touches (lace and beads) often styled over a printed dress were heavily featured. Missoni’s signature pattern (multi colored zigzags and stripes) again found vogue in the mid 90s, there was very much a mixing of old and new technologies ^[3].

Numerous Authors have commented that design education has not moved with the available technology resulting in designers with very little technical knowledge (with notable exceptions) and thus heavily reliant on technologists and technicians to interpret their ideas, in the same way they depend on pattern-cutters for woven fabrics ^[1,3]. Brackenbury comments that books on clothing technology are many, with just a mere reference to knitted goods, however his book recognizes the ‘particular attributes of knitted fabrics and their handling to produce garments that are both special and unique’ ^[1]. Perhaps this indicates that knitwear is striving to become a fashion in itself, worthy of its own special place in

history, a view perhaps considered by Black ‘...knitwear is regularly an invisible but staple element of many collections – not often shown on the catwalk but a significant turnover nevertheless’ ^[3]. If we take a look at Pringle the image we conjure up is “knitwear”, yet Pringle (since 2000) in itself is a whole collection including accessories ^[15]. It appears that knitwear is the driving force here, which appears to be an image reflected in many British branded collections. It is true that all the brands have re-positioned themselves within the luxury category and redefined their market by establishing ranges (e.g.: red, golf). Head of manufacturing at Pringle, Colin Anderson is reported to comment on the repositioning of Pringle ‘...it’s all about technical innovation during knitting and finishing to give a unique selling point’ ^[15], which is clearly demonstrated in its new cashmere garments (2005) produced from 2/28 yarn.

Technology advancing towards complete garment production

It was reported that during the 1995 ITMA exhibition in Milan knitting technology came of age ^[16]. The technology became more accessible and more responsive to new ideas and it is demonstrated through fashion designers increasingly exploiting the technology of knitting within their collections. Black comments on ... the increasing use of integral shaping in sweaters we see in the mainstream market, and the extraordinary range of pattern and construction now available in tights and stockings’ ^[3]. More features were made of seams i.e. the style lines became prominent features. However, the most noticeable influence of modern technology within fashion is that shaped garments have become mainstream fashion utilizing predominantly acrylic yarns, to create less expensive garments with that hallmark of quality, (New Look, H & M). Due to advanced technical developments during the 90s; Shima SES Compact digital machines capable of producing fully-fashioned pieces knitted sequentially and SES 122RT with its

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extra set of small needlebeds positioned above the normal knitting area to facilitate the knitting of shaped ribs ^[16], quality knitting is no longer limited to the elitist traditional manufacturers. This was very much apparent with all the talk of complete garment production during the 90s ^[14] and by 1995 Shima had satisfied this speculation by launching its revolutionary first generation of Wholegarment machines (SWG-X and SWG-V). Hence, providing shaping knowledge to an open market. According to Shima, the whole garment technology within fashion has been evolutionary rather than the predicted revolution ^[17]. Many industry experts evaluated this to mean the industries mind-set has not progressed at the same pace as the technical developments ^[17]. But in reality it could be that the product range capability of the first machines was too restrictive for the fashion arena (the early machines were only capable of knitting basic style lines) ^[17].

The move into the millennium

By the late 90s fully-fashioned knitwear became the common style on the market with shapes get smaller and more tailored. The fashioned shoulder technique used for traditional manufacture of high quality goods became a hallmark of knitted quality ^[16]. This is probably an indication that manufacturers are coming to terms with their new machinery and shaping techniques, and the flawed designer/technician partnership was becoming more harmonious. The knitted dress was given new exposure by the likes of Macdonald and Lainey Keogh creating inspirational pieces for their collections ^[3] and much effort was placed on finishing trims to create a smoother and more modern look, in many cases trims became integral. Eventually fashion geared towards the craft look, which prompted chunky knitting promoting a general knitwear revival ^[3].

The 21st century

Fashion styling and lifestyle had become a key feature in fashion at the birth of the new millennium. It is the era of “sexy”, as feminine style lines take to the catwalk. This is important for knitwear due to the comfort and conformity of the structures. During the late 90s and early in the new millennium the luxury market grew and cashmere was brought to the forefront of fashion adding a glamorous edge, aided by influential fashion designers, Prada and Louis Vuitton by Marc Jacob. They promoted ladylike styling; a classic knit with a woven skirt, with the addition of a cashmere basic slung over the shoulders or tied loosely around the waist ^[3]. It became widely accepted that luxury UK knitwear required a point to sale to attract customers ^[15]. Research acknowledged that women will buy a cashmere sweater solely as a fashion statement – however if she has wealth, other factors such as color, seasonal fashion, fit and comfort will be key factors for luxury ^[15]. A male however has not much interest in seasonal fashion he invests in a luxury sweater every 3 years at high cost ^[15]. However, in contrast other Authors appreciate the turn in men’s knitted fashion at the dawn of the new millennium and relate this to influences from continental trends. Comme des Garcon, Dries Van Noten and Kenzo have all used combinations of color and patterning to subvert the traditional classic mans sweater ^[3]. Even the twin-set has filtered into the early 2000s men’s designer knitwear sector. Cinc is a label producing exclusive cut and sew twin-sets for men from a combination of different structures and yarns. Designers such as Kenzo are reported to have a high proportion of their collections in knitwear ^[3] and the move at the end of 2001 is for luxury chunky knits.

Since the skeptical 90s there has been a lot of technological development regarding developing specialist machines to produce complete garments. It was noticeable that this technology was inhibited primarily by perception. However, 2003/04 saw the first

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examples of complete garments appearing in the shops. It appears that seamless technology is a way forward for the West to capture a niche market. However, it is questionable whether marketing the seamless feature of a garment, is adding benefit to the consumer. M & S and oasis are certainly examining this possibility by including swing tags on the labels ^[19]. There were many doubtful reports that the commercial garments produced on wholegarment were too simplistic for today's discerning buyer ^[19]. However, recent machinery investment represents a major commitment (especially in Italy) and belief in the technology, so it appears it is here to stay. Research conducted by Knitting International illustrated that this technology is now being accepted by major retailers and internationally known brands and is set to grow its share of the knitwear market ^[19]. Hunter identified usage with many ranges, listed are some examples MaxMara weekend range, DKNY Jeans, Versace, Burberry, McQueen, Simona Barbieri (Italy), Maglificio Imapier based in Barletta (south east Italy) ^[19]. The situation of 2005 is reported to fall into two categories; cheap yarns with elastomeric for young chains, Holmes estimates '...that 35/40 % of all apparel in developed markets may contain some elastane in filament form' ^[20]; or those trying to incorporate new technology into the fashion domain ^[19].

By autumn 2005 the mood was very much about quality, pointelle knits are the vogue and there is also interest in the crafted style. Smedley's is exclusively merino lambswool, and for summer high quality (Switzerland) sea island cotton ^[21]. Trends for 2005 spring were geared toward lightweight fine gauge knits (12 gauge etc) ^[21]. Traditional UK companies such as Pringle and Ballantyne have to be more innovative within the ranges having both classics key items and contemporary directions in their garments. It is interesting to note that both Pringle and Smedley in recent reports claim to be design led ^[15, 22]. Yet with technology moving at the current pace it is unlikely that technology is

not playing the key facilitator. Hunter reports that the main trend in garment technology in 2004 was a wider range of gauges especially course gauge, larger bed widths for larger sizes and improved yarn feeding systems ^[14]. In terms of technological innovation, advancement has been limited in these recent years and again design is feeding from the previous technical developments. Hence, the statement 'Technology is not the leader. New Technology has to handle our design requirements' ^[15]. This is still giving the impression that in this techno age technological developments lead, followed by a period where design explores the boundaries of the technology and then the cycle repeats.

Technology at its best

There were many technological breakthroughs in the knitting machinery within the millennium period, the importance of the technologies influence/partnership with design was demonstrated in the first International Knitting Machinery Exhibition (IKMA) held late 2003 in Milan. This was the knitting industry breaking away from the prestigious long running general textile fair (ITMA) signifying the growing strength of this method of textile manufacture and its stand alone status both in terms of textile fabrics and design innovation. Certainly the concept of complete garment manufacture has had its critics over the last decade, comments have been made regarding the versatility of the machine and the skills required to operate the technology. Machine builders in recent years have concentrated on the user-friendly concept in terms of programming the new technology (which since 1995 has become much more reliable), the hope is that this will increase industry acceptance of the new complete garment concept ^[17]. Is this a self-confession from the machine builders that there is an ever-widening gap between technology and design? Hence, could the situation be that technology is too advanced for the current trained knitwear designers,

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are designers now being driven by inspirational technicians and machine capability? Shima appears to be expanding heavily in marketing the “techno” concept and is quick to establish that ‘it’s the technical breadth of the Whole Garment samples ...’ which is ‘...the key to the technology’s future’ [17]. The new First machine has the capacity to produce a wide range of shoulders, necklines and armholes, which claim to conform to the human figure. Is this design innovation or technological? In addition there appears to be a huge marketing strategy behind the 3-D product, Shima provides a hanger rack and a DVD player for promotional videos aimed at the passing customer, not to mention the specially designed coat hangers and digital fitting room linked via a computer to store customer details [17]. However, it is difficult to establish if the consumer will understand this technology, after all it takes some know-how to distinguish from other methods of makeup and there appears to have been very little work conducted into consumer perception in relation to technology?

Notable developments of the millennium

Multi gauge by Stoll creates novel interplay between finely knit and loose areas. According to Spencer ‘Sophisticated fashion tastes have on occasions, required knitwear garments containing zones of both coarse and fine gauge stitches’ [2]. Steiger Taurus is seen as a development to watch, the Taurus consists of 12 independently motorized yarn carriers hence, no cam box, therefore, facilitating direct feeding of yarn [16]. In addition there are also new needles that facilitates fashioning, each with an individual linear motor, the front and back plates are synchronized but independently driven [16, 18]. A further advancement within pattern creation is a machine launched at the end of 2004 which appears to have gained ground in men’s wear, the “Intarsia enabled machine” (a flatbed with the option of 30 intarsia carriers) this has proved popular in the last year (2005) especially in Italy [17,23].

One Final development that has probably created the biggest technology debate in knitwear is complete garment production, although this concept was around in the 60’s it has taken some 40+ years to become a commercial reality. Shima Seiki is reported to be a pioneer of complete garment manufacture with no fewer than five machines [14]. It is reported that Shima sold 700 Whole Garment machines in 2003 [18], which were based on the foundation of the glove machine developed in the 60s. By the summer of 2004 Shima were inspiring their customers by providing a “kindness” concept to whole garment knitting. Garments have been produced utilizing a variety of yarns, that are comfortable, breathable and in high fashion [18]. According to Hunter 15% of the larger machine builder’s output is complete garment machines [16]. This is a good indicator of how far the technology has moved forward. In addition it is reported that ‘Garment quality has also improved dramatically and designers now seem to be inspired by the possibilities of the new technology’ [16].

‘...By keeping knitwear fashionable and helping to supply new styles on demand it also means less wastage and fewer sell-offs. What we must remember is that fashion sells knitwear as opposed to bulk textile products, for example. If we do not keep fashion fresh then knitwear will lose market share to other technologies such as weaving. Fashion must be allowed to drive the knitwear market’ [18]. Dr Shima is reported to state ‘...I believe that the culture of knitwear fashion could be in jeopardy. Therefore, the developed countries need to take back this industry, at least in part, in order to keep knitwear fashion both new and dynamic’ [18]. Mowbary quotes Dr Shima ‘Knitwear can now be much more than just a two-dimensional apparel item constructed from flat panels and sleeves’ [18]. Integral knitting is commonly used in knitwear but with complete garment knitting, is it possible to lead the whole industry forward? High fashion content, low labor intensive - Dr

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Shima stated in 2004 that there is really nothing like it in any other area of textiles [18].

The classics hang in

In 2001 Spencer estimated that ‘...over 7 million tons of knitted goods are produced annually throughout the world’ [2]. The traditional hose is now a niche market with just a few specialist knitters producing fully-fashioned stocking. Straight bar frames are still being produced according to Spencer, but existing machines are being modified to improve patterning and shaping facilities [2]. Many traditional UK luxury brands still operate straight bar frames, however increasingly more are enhancing their classic ranges with modern electronic V-bed manufacturing; Pringle, Smedley, Ballantyne (in some cases with 3-D shaping facilities), machines that are capable of structured knits without decreasing the ability to shape. It should be noted that the traditional skills of knitting hand-laying intarsia are still sought after in the classic British brands [21].

Where now?

There is no question that technology has opened up new areas of innovation and much potential in terms of design; Black acknowledged in 2002 that ‘Looking to the future, the new technologies offer exciting potential for new forms of industrial knitting which have yet to be fully exploited’ [3]. It appeared that this was the logical progression, since trimless or integral trims have become a commercial reality. According to Black trimless is now classed as the ‘norm’, this amounts to the ability to be able to shape integrally as apposed to the selvedge areas [3]. This can easily be verified from a quick market analysis of the UK classic brands.

What will be a challenge is the evolution of complete garment technology into other specialist knitting areas such as intarsia [15] and patterning of fully-fashioned seams [21].

Machine builders are certainly moving forward, finding innovative methods of exploiting the development of complete garments, as recently as 2005 Stoll has filed a patent relating to knitting the body then continuing onto the sleeve [24]. But in reality does the general fashion consumer understand and appreciate this technology? Walker shares the opinion (with others) that customer’s cannot differentiate between fully-fashioned and complete garment [21]. What is certain however is a consumer can appreciate quality; if quality is associated with the new technology there will be market value [21].

Whole garments have finally taken off in the competitive sportswear market; tennis stars (Lindsay Davenport) at Wimbledon Championships wore garments without seams [17]. Perhaps this is where seamless technology will best be appreciated, this view is shared by Anderson who predicts over the next 5 years seamless will have a phenomenal future and will be marketed for comfort and movement [15]. However other industry specialists see Whole Garment technology addressing the skills shortage in UK [21] a view the machine manufacturers have tried hard to suppress [17].

Summary

Knitwear has demonstrated throughout the ages that it can swiftly adapt to change in demand and the many trends of fashion. In the 80s Mason acknowledged that knitwear influences fashion and therefore new demands are stimulated [6]. The advantage of knitwear is that style changes are speedy in comparison with other textile industries; this flexibility is reported to account for some of fashion knitwear’s success. Although the technique of knitting to shape has been utilized for centuries in quality knitwear, modern technology has enabled knitted constructions in shaped form to expand into the fashion market. Traditional fully-fashioned manufacture has ‘...suffered a considerable decline in fashion demand during the 20 century as a result of the

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improvement of cheaper manufacturing techniques in other sectors of weft knitting...'^[2]. Over the past thirty years, the level of design innovation evident in knitwear has advanced tremendously^[3]. Flat-bed weft knitting today is a computer controlled highly efficient and versatile knitting tool for; cut and sew, fully-fashioned, integral knitting and complete garment. In Spencer's opinion, the biggest challenge for the flat-bed knitting machine is when fashion swings from knitwear to t-shirts^[2] but in reality is this ever likely to happen given knitwear's strong fashion following? In addition knitwear varies from mass market to couture and it is worth mentioning that a small amount of fashion collections are knitwear led^[3]. Market analysis clearly demonstrates that there has been a steady increase in the UK knitwear market from approx £1,764 million in 1998 to £2338 million in 2003^[26]. Knitwear has now become accepted as a contemporary fashion item, as recently as March 2006 lifestyle brand Joules appointed a knitwear designer thus, indicating this products strength within a brand^[27].

With the exception of the silk hose, fashion knitwear can generally be credited to the post war period. There was little development in terms of technology around this period and much focus was given to reinventing already existent knitted fabrics. The structures previously used for underwear moved to external coverings promoted by designers such as Chanel. This created a two tier knitting industry – quality and fashion, by 1930 knitwear had recovered in the UK, leading into an era of styling inbetween the war years. This was the greatest directional move of knitwear, bringing the structures into the forefront of fashion, and ultimately changing the perception of knits as functional clothing. During this period shortfalls were identified in design education and to some extent design was catching up with the technology of the day. The 50s and 60s were very much about technological developments however; there was a distinct lack of electronic

development at this time to fulfill the innovation of the machine builders. Warp knitting increased its market share from the woven markets in men's shirts and Jaeger's branded knitwear saw huge growth in its export range. In fashion terms the 60s is credited to the double jersey/jacquard boom, which is reported to be a result of technological advancement. By the 70s the jersey bubble burst and again quality knitwear became the innovator taking influence from the Italian styling - Missoni was the talk of the fashion world. Again design innovating knitted fashion but the gap was closing. By the late 70s/early 80s knitwear was back at the forefront of fashion promoted by the fitness craze (Lycra was a prominent contributor in this period). The 90s introduced partial knitting, which was paramount in flatbed knitting gaining ground in the traditional fully-fashioned markets. Later cheap imports caused a rethink in the UK and European markets; it was very much about survival. Much emphasis was placed on flatbed development and again the gap between design and technology grew as designers struggled to keep up with technical innovation. Within the 90s again there was pause for reflection as designers came to terms with the boundaries of the new technology. There was a strong focus on integral knits; however, by this period technology is moving at a tremendous pace with a clear strategy regarding complete garment production. The millennium brought with it glamorous sights of commercially knitted complete garments, however it is worth noting that the styling was basic until techniques were refined. Does this signify design or technological innovation? This research concludes that throughout history there appears to be periods of innovation were technology leads design, followed by periods of development were design exploits the technological capability and then the cycle repeats. It is unlikely that design can led the advances in technology, therefore there are grounds to believe technology is providing a valuable tool for design, and fashion would do well to

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recognize the valuable contribution of innovative technicians who have been the facilitators of knitwear's repositioning in history from functional to fashionable clothing.

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